U.S. DEPARTMENT OF COMMERCE
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PB-256 667

Oradell Reservoir
Bergen County, New Jersey

National Environmental Res. Ctr.

Prepared For
Pacific NW Environmental Res. Lab.

May 1976

243125

PB 256 667

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

P.O. 699-440

REPORT

ON

ORADELL RESERVOIR

BERGEN COUNTY

NEW JERSEY

EPA REGION II

WORKING PAPER NO. 370

WITH THE COOPERATION OF THE

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

AND THE

NEW JERSEY NATIONAL GUARD

MAY 1976

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Oradell Reservoir, Bergen County, New Jersey		5. REPORT DATE Prepared May 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper No. 370
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency P.O. Box 15027 Las Vegas, NV 89114		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared in cooperation with the U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Eutrophication Survey Branch, Corvallis, OR 97330

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release unlimited		42
	20 SECURITY CLASS (This page)	22. PRICE 4.00

A Form 2220-1 (9-73)

PRICES SUBJECT TO CHANGE

CONTENTS

	Page
Foreword	ii
List of Study Lakes - State of New Jersey	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	3
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	9
V. Literature Reviewed	13
VI. Appendices	14

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the New Jersey Department of Environmental Protection for professional involvement and to the New Jersey National Guard for conducting the tributary sampling phase of the Survey.

Douglas Clark, Chief of the Bureau of Water Quality Planning and Management, Mr. Frank Takacs, New Jersey National Eutrophication Survey Coordinator, Principal Environmental Specialist, and Robert Kotch, Senior Environmental Engineer, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

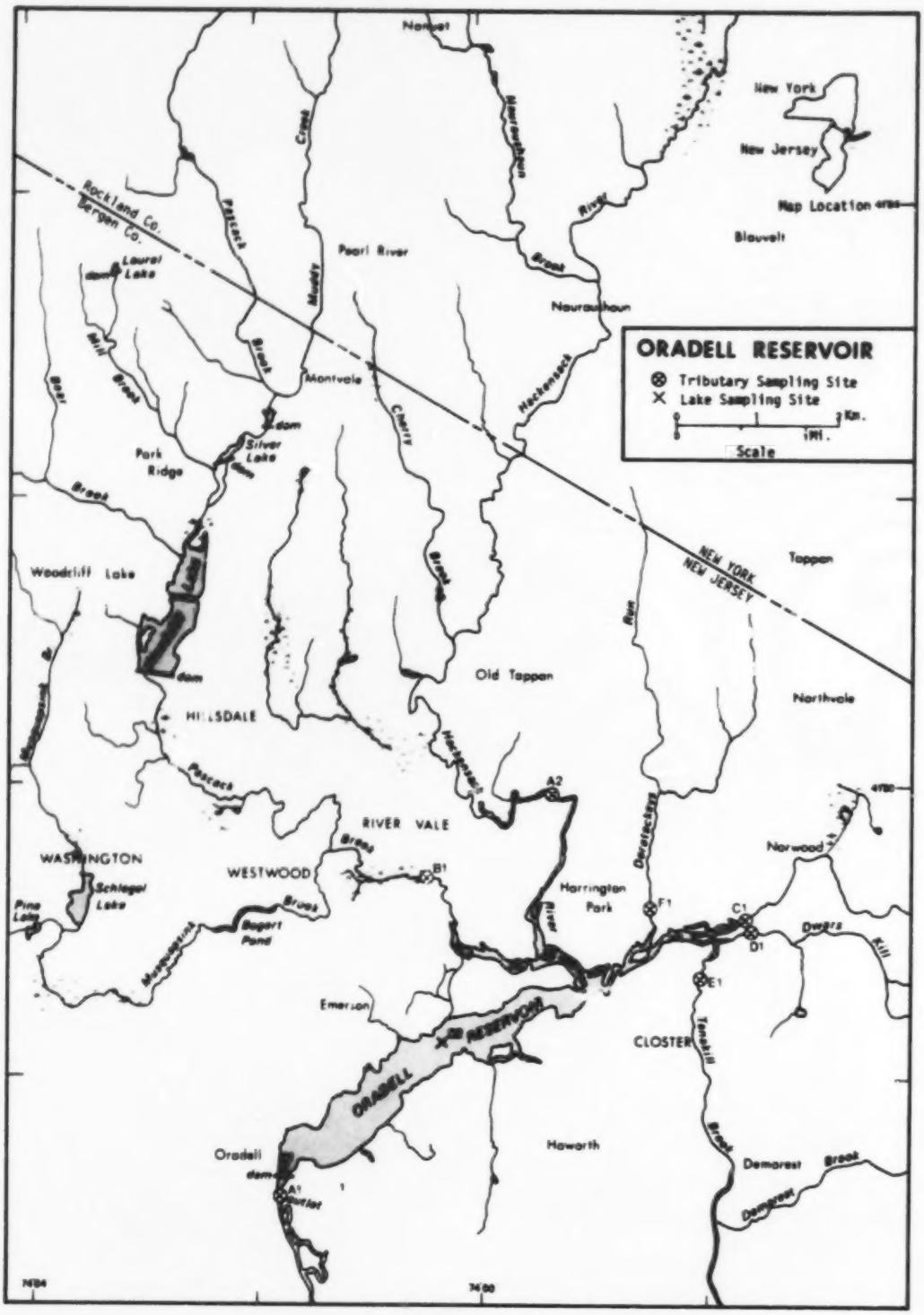
Major General William R. Sharp, Former Chief of Staff, Major General Wilfred G. Menard, Jr., Chief of Staff, and Project Officer Colonel Herbert D. Ruhlin, who directed the volunteer efforts of the New Jersey National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF NEW JERSEY

LAKE NAME	COUNTY
Budd Lake	Morris
Duhernal Lake	Middlesex
Farrington Lake	Middlesex
Greenwood Lake	Passaic, N.J.; Orange, N.Y.
Lake Hopatcong	Morris, Sussex
Lake Musconetcong	Morris, Sussex
Oradell Reservoir	Bergen
Paulinskill Lake	Sussex
Pinecliff Lake	Passaic
Pompton Lakes	Passaic
Spruce Run Reservoir	Hunterdon
Union Lake	Cumberland
Wanaque Reservoir	Passaic


ORADELL RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Km.
Mi.
Scale
New York
New Jersey
Map Location
Blauvelt
Rockland Co.
Bergen Co.
Pearl River
Nauraushaun
Montvale
Park Ridge
Woodcliff Lake
Old Tappan
Tappan
Northvale
HILLSDALE
RIVER VALE
WASHINGTON
WESTWOOD
Harrington Park
Norwood
Emerson
CLOSTER
Haworth
Oradell
Demarest
Schlegel Lake
Pine Lake
Bogert Pond
Laurel Lake
Silver Lake
NEW YORK
NEW JERSEY
A1
A2
B1
C1
D1
E1
F1

ORADELL RESERVOIR, NEW JERSEY

STORET NO. 3406

I. CONCLUSIONS

A. Trophic Condition:

Based upon field observations and Survey data, Oradell Reservoir is considered eutrophic. The lake is characterized by high nutrient concentrations, summer depression of dissolved oxygen at Station 2, and spring and autumn algal blooms. The mean Secchi disc reading in this turbid, brownish-green lake was 95 cm, and chlorophyll a levels were high, ranging from 11.7 µg/l in the summer to 33.0 µg/l in the spring.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Oradell Reservoir is limited by available phosphorus. Spikes with phosphorus, or phosphorus and nitrogen simultaneously resulted in increased assay yields. The addition of nitrogen alone did not produce a growth response. The mean total inorganic nitrogen to orthophosphorus ratio (N/P) further substantiates these results.

C. Nutrient Controllability:

1. Point Sources -

There are no known point sources impacting Oradell Reservoir. The phosphorus loading for Oradell Reservoir of 5.08 $g/m^2/yr$ is 3.2 times above the "dangerous" loading proposed by Vollenweider (Vollenweider and Dillon, 1974).

2. Non-point Sources -

Non-point sources contributed all the loading reaching Oradell Reservoir. Measured tributaries contributed 88.9% of the total phosphorus load while minor tributaries contributed 10.8% of the total load.

Determination of surrounding land uses and unknown sources contributing loading is necessary before recommendations for lake improvement can be proposed.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by D. L. Hoven, Hackensack Water Company; tributary flow data were provided by the New Jersey District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by the mean flow of the outlet. The mean flow of the outlet includes the flow diverted from Oradell Reservoir for a municipal water supply. The sum of the tributary flows do not equal the outlet flow probably because of either sampling error, unmeasured groundwater influence or unknown inputs reaching the lake. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 2.64 km^2.
2. Mean depth: 4.1 meters.
3. Maximum depth: 7.6 meters.
4. Volume: 10.789 x 10^6 m^3.
5. Mean hydraulic retention time: 23 days.

B. Tributaries and Outlet (see Appendix B for flow data)

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
A(2) Hackensack River	150.2	2.55
B(1) Pascack River	76.7	1.45
C(1) Unnamed Stream	5.3	0.08
D(1) Dwars Kill Stream	8.4	0.13
E(1) Tenakill Brook	22.2	0.50
F(1) Dorotockeys Run	11.0	0.17
Minor tributaries and immediate drainage -	17.0	0.29
Totals	290.8	5.17

2. Outlets -

A(1) Hackensack River	292.7	1.66
Diversion canal	---	3.77
Totals	292.7	5.43

C. Precipitation:

1. Year of sampling: 139.9 centimeters.

2. Mean annual: 105.5 centimeters.

III. LAKE WATER QUALITY SUMMARY

Oradell Reservoir was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 4.6 meters at Station 1 and 4.0 meters at Station 2. For a more detailed explanation of National Eutrophication Survey methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III B. Results of the limiting nutrient study are presented in III C.

GRADELL RESERVOIR
STONEY CODE 3406

PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(4/16/73)					(7/22/73)					(10/ 1/73)				
	S*** = 2					S*** = 2					S*** = 2				
	N*	RANGE		MEDIAN	MAX DEPTH RANGE (METERS)	N*	RANGE		MEDIAN	MAX DEPTH RANGE (METERS)	N*	RANGE		MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)															
0.-1.5 M DEPTH	2	10.1-	11.4	10.7	0.0- 0.0	4	25.1-	25.6	25.5	0.0- 1.5	3	19.8-	20.5	20.3	0.0- 1.5
MAX DEPTH**	2	9.9-	11.2	10.5	4.0- 4.3	2	23.6-	23.8	23.7	4.0- 4.0	2	19.4-	19.9	19.6	2.1- 4.6
DISSOLVED OXYGEN (MG/L)															
0.-1.5 M DEPTH	3	*****	*****	*****	*****-*****	2	7.0-	8.8	7.9	1.5- 1.5	1	9.8-	9.8	9.8	1.5- 1.5
MAX DEPTH**	2	9.3-	12.9	11.1	4.0- 4.3	2	1.4-	4.6	3.0	4.0- 4.0	2	8.4-	9.8	8.7	2.1- 4.6
CONDUCTIVITY (UMHOS)															
0.-1.5 M DEPTH	2	280.-	280.	280.	0.0- 0.0	4	245.-	294.	291.	0.0- 1.5	3	625.-	650.	625.	0.0- 1.5
MAX DEPTH**	2	280.-	280.	280.	4.0- 4.3	2	245.-	290.	268.	4.0- 4.0	2	625.-	650.	638.	2.1- 4.6
PH (STANDARD UNITS)															
0.-1.5 M DEPTH	2	7.4-	7.8	7.6	0.0- 0.0	4	8.1-	8.6	8.3	0.0- 1.5	3	7.7-	8.2	7.8	0.0- 1.5
MAX DEPTH**	2	7.4-	8.2	7.8	4.0- 4.3	2	7.3-	7.3	7.3	4.0- 4.0	2	7.6-	7.8	7.7	2.1- 4.6
TOTAL ALKALINITY (MG/L)															
0.-1.5 M DEPTH	2	64.-	66.	65.	0.0- 0.0	4	76.-	80.	79.	0.0- 1.5	3	79.-	86.	84.	0.0- 1.5
MAX DEPTH**	2	66.-	71.	69.	4.0- 4.3	2	78.-	88.	79.	4.0- 4.0	2	84.-	85.	85.	2.1- 4.6
TOTAL P (MG/L)															
0.-1.5 M DEPTH	2	0.039-	0.056	0.044	0.0- 0.0	4	0.039-	0.057	0.049	0.0- 1.5	3	0.051-	0.089	0.069	0.0- 1.5
MAX DEPTH**	2	0.037-	0.055	0.046	4.0- 4.3	2	0.063-	0.101	0.082	4.0- 4.0	2	0.059-	0.075	0.067	2.1- 4.6
DISSOLVED ORTHO P (MG/L)															
0.-1.5 M DEPTH	2	0.007-	0.010	0.008	0.0- 0.0	4	0.006-	0.010	0.008	0.0- 1.5	3	0.008-	0.009	0.008	0.0- 1.5
MAX DEPTH**	2	0.007-	0.008	0.007	4.0- 4.3	2	0.014-	0.019	0.016	4.0- 4.0	2	0.007-	0.010	0.008	2.1- 4.6
NO2+NO3 (MG/L)															
0.-1.5 M DEPTH	2	1.000-	1.100	1.050	0.0- 0.0	4	0.720-	0.860	0.740	0.0- 1.5	3	0.520-	0.620	0.530	0.0- 1.5
MAX DEPTH**	2	1.000-	1.100	1.050	4.0- 4.3	2	0.780-	0.800	0.790	4.0- 4.0	2	0.530-	0.580	0.555	2.1- 4.6
AMMONIA (MG/L)															
0.-1.5 M DEPTH	2	0.060-	0.080	0.070	0.0- 0.0	4	0.060-	0.130	0.090	0.0- 1.5	3	0.060-	0.120	0.080	0.0- 1.5
MAX DEPTH**	2	0.050-	0.080	0.065	4.0- 4.3	2	0.230-	0.410	0.320	4.0- 4.0	2	0.050-	0.160	0.105	2.1- 4.6
KJELDAHL N (MG/L)															
0.-1.5 M DEPTH	2	0.500-	0.700	0.600	0.0- 0.0	4	0.700-	2.400	0.800	0.0- 1.5	3	1.200-	1.400	1.300	0.0- 1.5
MAX DEPTH**	2	0.400-	0.500	0.450	4.0- 4.3	2	0.700-	0.900	0.800	4.0- 4.0	2	1.100-	1.200	1.150	2.1- 4.6
SECCHI DISC (METERS)	2	0.9-	0.9	0.9		2	1.0-	1.1	1.0		2	0.8-	1.0	0.9	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/16/73	1. Asterionella	11,445
	2. Stephanodiscus	5,970
	3. Flagellates	4,521
	4. Lagerheimia	650
	5. Melosira	198
	Other genera	558
	Total	23,342
07/22/73	1. Fragilaria	2,011
	2. Sphaerocystis	1,638
	3. Oocystis	498
	4. Coelastrum	352
	5. Centric diatom	269
	Other genera	1,017
	Total	5,785
10/01/73	1. Fragilaria	15,566
	2. Coelastrum	986
	3. Pediastrum	386
	4. Melosira	429
	5. Flagellates	300
	Other genera	1,158
	Total	18,825

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/liter)
04/16/73	1	21.5
	2	33.8
07/22/73	1	13.0
	2	11.7
10/01/73	1	30.2
	2	23.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.020	0.910	5.2
0.05 P	0.070	0.910	15.5
0.05 P + 1.0 N	0.070	1.910	19.5
1.00 N	0.020	1.910	5.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary productivity was high in Oradell Reservoir at the time of sampling. The lake was phosphorus limited at that time as indicated by the increased yield of the test alga in response to an addition of orthophosphorus. Spikes with phosphorus and nitrogen simultaneously resulted in a maximum yield. Spikes with nitrogen alone did not produce any response beyond the control yield. The N/P ratio in the spring lake data was 140/1, indicating phosphorus limitation at that time. The N/P ratios for summer and fall were greater than 69/1, also suggesting phosphorus limitation in Oradell Reservoir.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the New Jersey National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in July 1973, and was completed in July 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the New Jersey District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any. The total outlet load was calculated by multiplying the total outlet flow (mean flow of tributary A(1) plus mean flow of the diversion canal) times the concentration measured at Station A(1). This assumes that the nutrient concentration at A(1) is the same as that flowing out of the aqueduct.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual concentrations in Unnamed Stream at Station C(1), Dwars Kill at Station D(1) and Dorotockey's Run at Station F(1) and mean annual ZZ flow.

A. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A(2) Hackensack River	4,455	33.2
B(1) Pascack River	4,100	30.5
C(1) Unnamed Stream	345	2.6
D(1) Dwars Kill Stream	790	5.9
E(1) Tenakill Brook	1,385	10.3
F(1) Dorotockey's Run	855	6.4
b. Minor tributaries and immediate drainage (nonpoint load) -	1,445	10.8
c. Known municipal STP's - None		
d. Septic tanks - None		
e. Known industrial - None		
f. Direct precipitation* -	45	0.3
Totals	13,420	100.0
2. Output - A(1) Hackensack River	9,075	
3. Net annual P accumulation -	4,345	

*Estimated (see NES Working Paper No. 175).

B. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A(2) Hackensack River	146,990	38.8
B(1) Pascack River	107,030	28.2
C(1) Unnamed Stream	8,180	2.2
D(1) Dwars Kill Stream	13,460	3.5
E(1) Tenakill Brook	55,370	14.6
F(1) Dorotockey's Run	16,990	4.5
b. Minor tributaries and immediate drainage (nonpoint load) -	28,315	7.5
c. Known municipal STP's - None		
d. Septic tanks - None		
e. Known industrial - None		
f. Direct precipitation** -	2,850	0.7
Total	379,185	100.0

2. Output - A(1) Hackensack River 334,435

3. Net annual N accumulation - 44,750

*Estimated (see NES Working Paper No. 175).

C. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
A(2) Hackensack River	30	979
B(1) Pascack River	53	1,395
C(1) Unnamed Stream	65	1,543
D(1) Dwars Kill Stream	94	1,602
E(1) Tenakill Brook	62	2,494
F(1) Dorotockey's Run	78	1,545

D. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Yearly Phosphorus Loading (g/m²/yr)
Estimated loading for Oradell Reservoir	5.08
Vollenweider's "dangerous" or eutrophic loading	1.58
Vollenweider's "permissible" or oligotrophic loading	0.79

V. LITERATURE REVIEWED

Hoven, Donald L. Personal communication, regarding lake morphometry. Hackensack Water Company, Water Quality Control and Treatment Division. Weehawken, New Jersey.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. Environmental Monitoring and Support Laboratory, Las Vegas, Nevada and Corvallis Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NEW JERSEY 06/04/76

LAKE CODE 3406 ORADELL RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 292.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3406A1	292.7	1.05	2.04	4.53	2.97	2.21	2.07	1.08	0.71	1.05	0.27	0.71	1.27	1.66
3406A2	150.2	2.72	2.97	4.81	4.11	2.94	1.78	1.93	1.90	1.39	1.42	2.29	2.41	2.55
3406B1	76.7	1.50	1.64	2.46	2.32	1.64	1.13	1.10	1.08	0.93	0.93	1.27	1.39	1.45
3406C1	5.3	0.085	0.108	0.164	0.159	0.102	0.057	0.042	0.045	0.040	0.037	0.062	0.074	0.081
3406D1	8.4	0.136	0.167	0.255	0.241	0.159	0.091	0.071	0.076	0.065	0.062	0.102	0.116	0.128
3406E1	22.2	0.57	0.59	0.99	0.79	0.51	0.31	0.26	0.27	0.27	0.31	0.48	0.59	0.50
3406F1	11.0	0.178	0.218	0.340	0.311	0.210	0.119	0.093	0.099	0.085	0.082	0.133	0.153	0.168
3406ZZ	19.0	0.31	0.37	0.57	0.54	0.37	0.21	0.16	0.17	0.15	0.14	0.23	0.26	0.29

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 292.7
SUM OF SUB-DRAINAGE AREAS = 292.7

TOTAL FLOW IN = 62.86
TOTAL FLOW OUT = 19.95

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3406A1	7	73	1.246	21	0.708				
	8	73	0.708	19	0.510				
	9	73	0.595	16	0.566				
	10	73	0.085	14	0.028				
	11	73	0.028	11	0.028				
	12	73	3.256	8	0.028				
	1	74	2.747	26	1.614				
	2	74	2.549	9	1.218	24	4.163		
	3	74	4.248	10	5.720	24	5.125		
	4	74	7.702	7	7.164				
	5	74	1.161	19	0.510				
	6	74	0.680	2	0.595				
3406A2	7	73	1.954	21	8.325				
	8	73	2.039	19	0.821				
	9	73	2.973	16	4.587				
	10	73	2.464	14	3.200				
	11	73	0.934	11	0.510				
	12	73	1.076	8	0.566				
	1	74	1.444	26	0.850				
	2	74	2.549	9	2.039	24	3.766		
	3	74	3.200	10	3.766	24	4.332		
	4	74	4.701	7	5.522				
	5	74	2.294	19	1.812				
	6	74	1.388	2	3.256				

TRIBUTARY FLOW INFORMATION FOR NEW JERSEY 06/04/76

LAKE CODE 3406 ORADELL RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3406B1	7	73	1.586	21	4.672				
	8	73	1.048	19	0.793				
	9	73	1.161	16	1.472				
	10	73	0.906	14	0.765				
	11	73	0.963	11	0.850				
	12	73	2.775	8	1.218				
	1	74	1.784	26	1.812				
	2	74	1.501	9	1.303	24	1.642		
	3	74	1.841	10	1.642	24	1.699		
	4	74	2.577	7	2.322				
	5	74	1.869	19	1.444				
	6	74	1.586	2	1.642				
3406C1	7	73	0.085	21	0.425				
	8	73	0.105	19	0.051				
	9	73	0.048	16	0.045				
	10	73	0.085	14	0.023				
	11	73	0.059	11	0.037				
	12	73	0.266	8	0.079				
	1	74	0.173	26	0.167				
	2	74	0.125	9	0.102	24	0.113		
	3	74	0.187	10	0.184	24	0.187		
	4	74	0.244	7	0.215				
	5	74	0.147	19	0.102				
	6	74	0.082	2	0.113				
3406D1	7	73	0.136	21	0.680				
	8	73	0.159	19	0.082				
	9	73	0.079	16	0.076				
	10	73	0.136	14	0.042				
	11	73	0.093	11	0.062				
	12	73	0.396	8	0.125				
	1	74	0.263	26	0.258				
	2	74	0.198	9	0.164	24	0.178		
	3	74	0.283	10	0.283	24	0.283		
	4	74	0.368	7	0.340				
	5	74	0.227	19	0.156				
	6	74	0.133	2	0.178				
3406E1	7	73	0.368	21	0.425				
	8	73	0.184	19	0.153				
	9	73	0.142	16	0.153				
	10	73	0.215	14	0.136				
	11	73	0.212	11	0.176				
	12	73	1.161	8	0.119				
	1	74	0.708	26	0.878				
	2	74	0.518	9	0.340	24	0.850		
	3	74	0.821	10	0.878	24	0.991		
	4	74	0.991	7	1.076				
	5	74	0.595	19	0.481				
	6	74	0.283	2	0.566				

TRIBUTARY FLOW INFORMATION FOR NEW JERSEY 06/04/76

LAKE CODE 3406 ORADELL RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3406F1	7	73	0.178	21	0.906				
	8	73	0.210	19	0.108				
	9	73	0.105	16	0.099				
	10	73	0.178	14	0.057				
	11	73	0.122	11	0.082				
	12	73	0.510	8	0.164				
	1	74	0.340	26	0.340				
	2	74	0.261	9	0.215	24	0.235		
	3	74	0.368	10	0.368	24	0.368		
	4	74	0.481	7	0.453				
	5	74	0.311	19	0.204				
	6	74	0.176	2	0.235				
3406ZZ	7	73	0.311	21	1.557				
	8	73	0.368	19	0.187				
	9	73	0.181	16	0.173				
	10	73	0.311	14	0.096				
	11	73	0.212	11	0.142				
	12	73	0.906	8	0.283				
	1	74	0.595	26	0.595				
	2	74	0.453	9	0.368	24	0.396		
	3	74	0.651	10	0.651	24	0.651		
	4	74	0.850	7	0.765				
	5	74	0.510	19	0.340				
	6	74	0.311	2	0.396				

APPENDIX C

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 76/06/04

340601
40 57 26.0 074 01 46.0 3
ORADELL RESERVOIR
34003 NEW JERSEY

013391

11EPALES 2111202
0018 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/16	10 35	0000	10.1		36	280	7.40	64	0.080	0.500	1.000	0.007
	10 35	0006	10.0	10.2		280	7.50	63	0.080	0.300	1.000	0.008
	10 35	0014	9.9	9.3		280	7.40	71	0.080	0.400	1.000	0.008
73/07/22	10 30	0000	25.6		44	291	8.60	80	0.060	0.800	0.720	0.007
	10 30	0005	25.6	8.8		291	8.50	80	0.060	0.700	0.720	0.010
	10 30	0013	23.6	1.4		290	7.30	88	0.410	0.900	0.780	0.014
73/10/01	13 15	0000	20.5		30	625	7.70	79	0.060	1.200	0.520	0.008
	13 15	0005	20.3	9.8		625	7.80	86	0.120	1.400	0.620	0.009
	13 15	0015	19.9	9.0		650	7.60	85	0.160	1.200	0.580	0.010

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/16	10 35	0000	0.050	21.5
	10 35	0006	0.045	
	10 35	0014	0.037	
73/07/22	10 30	0000	0.039	13.0
	10 30	0005	0.057	
	10 30	0013	0.063	
73/10/01	13 15	0000	0.089	30.2
	13 15	0005	0.069	
	13 15	0015	0.075	

21

STORET RETRIEVAL DATE 76/06/04

340602
40 58 17.0 074 00 20.0 3
ORADELL RESERVOIR
34003 NEW JERSEY

013391

11EPALES 2111202
0017 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/16	11	0000	11.4		36	280	7.80	66	0.060	0.700	1.100	0.010
	11	0006	11.4	12.9		280	8.10	65	0.050	0.500	1.100	0.008
	11	0013	11.2	12.9		280	8.20	66	0.050	0.500	1.100	0.007
73/07/22	10	0000	25.4		38	294	8.10	76	0.120	2.400	0.760	0.006
	10	0005	25.1	7.8		245	8.10	78	0.130	0.800	0.860	0.010
	10	0013	23.8	4.6		245	7.30	70	0.230	0.700	0.800	0.019
73/10/01	13	0000	19.8		41	650	8.20	84	0.060	1.300	0.530	0.008
	13	0007	19.4	8.4		625	7.80	84	0.050	1.100	0.530	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/16	11	0000	0.039	33.8
	11	0006	0.047	
	11	0013	0.055	
73/07/22	10	0000	0.042	11.7
	10	0005	0.057	
	10	0013	0.101	
73/10/01	13	0000	0.051	23.4
	13	0007	0.059	

22

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/06/04

3406A1
40 57 15.0 074 01 46.0 4
HACKENSACK RIVER
34 7.5 HACKENSACK
O/ORADELL RESERVOIR 013391
ORADELL AVE BRDG 0.1 MI S OF DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	10 00		0.690	0.690	0.147	0.005K	0.025
73/08/19	08 30		0.600	1.400	0.415	0.032	0.125
73/09/16	10 35		0.410	0.800	0.120	0.009	0.060
73/10/14	12 00		0.450		0.039	0.029	0.055
73/11/11	10 00		0.790	0.850	0.160	0.028	0.095
73/12/08	10 15		1.180	0.700	0.096	0.012	0.070
74/01/26	10 50		1.900	0.500	0.120	0.020	0.050
74/02/09	15 40		1.600	0.500	0.113	0.005	0.030
74/02/24	15 20		1.600	0.800	0.095	0.005	0.050
74/03/10	10 15		1.600	0.800	0.050	0.005	0.035
74/03/24	14 30		1.520	0.800	0.050	0.010	0.050
74/04/07	10 20		1.120	0.700	0.020	0.005	0.005
74/05/19	09 10		1.010	0.800	0.055	0.005	0.040
74/06/02	11 15		0.924	1.100	0.210	0.006	0.040
74/07/21	12 20		0.420	0.900	0.075	0.005K	0.025

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/06/04

3406A2
40 59 59.0 073 59 21.0 4
HACKENSACK RIVER
34 7.5 YONKERS
I/ORADELL RESERVOIR 013391
WESTWOOD AVE BRDG N OF RIVERDALE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	11 10		0.300	1.050	0.176	0.017	0.100
73/08/19	09 25		1.000	0.750	0.190	0.018	0.055
73/09/16	11 15		0.168	0.870	0.056	0.012	0.070
73/10/14	12 25		1.540	1.450	0.006	0.006	0.085
73/11/11	10 50		1.220	0.950	0.190	0.009	0.070
73/12/08	11 00		1.300	0.900	0.192	0.008	0.065
74/01/26	11 40		2.000	0.500	0.224	0.020	0.045
74/02/09	15 15		1.200	0.700	0.160	0.005K	0.035
74/02/24	15 05		0.960	0.800	0.125	0.005	0.050
74/03/10	11 00		1.000	1.000	0.110	0.005K	0.040
74/03/24	14 15		0.970	0.900	0.075	0.010	0.055
74/04/07	11 00		0.850	1.100	0.025	0.005	0.010
74/05/19	09 50		0.704	0.600	0.060	0.010	0.050
74/06/02	11 40		0.588	1.000	0.125	0.010	0.065
74/07/21	12 45		0.072	0.700	0.020	0.010	0.050

K VALUE KNOWN TO BE
LESS THAN INDICATED

25

STORET RETRIEVAL DATE 76/06/04

340681
40 59 27.0 074 00 28.0 4
PASCACK RD
34 7.5 HACKENSACK
T/ORADELL RESERVOIR 013391
BRDG ON RD BTWN RIVERDALE & OLD HOOK RDS
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	10 40		0.790	1.200	0.140	0.042	0.190
73/08/19	09 00		1.400	1.150	0.220	0.050	0.200
73/09/16	11 00		1.060	1.000	0.120	0.034	0.123
73/10/14	12 10		1.460	0.850	0.062	0.023	0.080
73/11/11	10 15		1.440	0.500	0.088	0.021	0.080
73/12/08	10 30		1.400	0.600	0.076	0.020	0.095
74/01/26	11 05		2.000	0.500	0.184	0.020	0.060
74/02/09	15 05		2.400	0.300	0.095	0.015	0.040
74/02/24	15 00		1.900	0.800	0.065	0.015	0.065
74/03/10	10 35		1.850	1.900	0.095	0.010	0.060
74/03/24	14 05		1.760	0.900	0.080	0.010	0.070
74/04/07	10 55		1.400	1.000	0.085	0.010	0.025
74/05/19	09 30		1.400	0.700	0.100	0.015	0.070
74/06/02	11 30		1.360	1.000	0.155	0.025	0.090
74/07/21	12 35		1.780	0.900	0.175	0.175	0.270

26

STORET RETRIEVAL DATE 76/06/04

3406C1
40 59 06.0 073 57 40.0 4
UNNAMED STREAM
34 7.5 YONKERS
T/ORADELL RESERVOIR 013391
BLANCHE AVE BRDG S OF LIVINGSTON ST JCT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	11 40		0.490	0.720	0.120	0.071	0.265
73/08/19	10 00		3.200	0.940	0.168	0.058	0.130
73/09/16	12 30		1.200	0.960	0.147	0.066	0.125
73/10/14	09 55		3.700	1.350	0.062	0.064	0.155
73/11/11	13 05		3.100	0.750	0.230	0.056	0.145
73/12/08	11 45		2.000	1.100	0.252	0.036	0.115
74/01/26	12 00		1.600	0.600	0.184	0.024	0.070
74/02/09	14 40		2.640	1.200	0.260	0.025	0.115
74/02/24	14 05		1.900	0.900	0.160	0.035	0.110
74/03/10	12 25		1.000	1.800	0.110	0.025	0.075
74/03/24	13 50		1.520	0.900	0.135	0.035	0.095
74/04/07	12 30		1.260	1.400	0.160	0.035	0.040
74/05/19	11 00		1.400	1.500	0.260	0.065	0.200
74/06/02	12 45		1.800	1.800	0.370	0.070	0.185
74/07/21	13 00		2.640	1.700	0.270	0.055	0.170

27

STORET RETRIEVAL DATE 76/06/04

3406D1
40 59 00.0 073 57 35.0 4
DWARS KILL
34 7.5 YONKERS
T/ORADELL RESERVOIR 013391
BLANCHE AVE BRDG S OF LIVINGSTON ST JCT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	13	10	0.610	0.980	0.132	0.076	0.290
73/08/19	10	10	3.800	0.790	0.300	0.170	0.175
73/09/16	12	40	2.600	1.100	0.378	0.273	0.315
73/10/14	10	00	2.060	1.950	0.535	0.675	0.700
73/11/11	13	20	2.800	1.430	0.330	0.220	0.360
73/12/08	13	10	2.500	1.400	0.320	0.092	0.220
74/01/26	12	05	2.100	0.200	0.124	0.040	0.075
74/02/09	14	45	3.000	0.600	0.175	0.040	0.065
74/02/24	14	30	2.520	0.600	0.125	0.045	0.090
74/03/10	12	25	1.440	1.300	0.100	0.035	0.075
74/03/24	13	45	1.900	0.400	0.087	0.040	0.060
74/04/07	12	40	1.800	0.600	0.105	0.040	0.055
74/05/19	11	05	2.000	0.600	0.115	0.025	0.065
74/06/02	12	50	2.100	1.300	0.185	0.035	0.075
74/07/21	13	05	1.850	0.300	0.075	0.045	0.055

28

STORET RETRIEVAL DATE 76/06/04

3406E1
40 58 43.0 073 58 01.0 4
TENAKILL BROOK
34 7.5 YONKERS
T/ORADELL RESERVOIR 013391
CEDAR LN BRDG E OF KNICKERBOCKER RD JCT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	13 30		0.950	1.250	0.138	0.060	0.210
73/08/19	10 20		3.600	0.600	0.120	0.340	0.055
73/09/16	12 40		2.500	0.750	0.132	0.043	0.110
73/10/14	10 55		3.500	0.700	0.046	0.030	0.075
73/11/11	14 15		3.360	0.850	0.220	0.027	0.115
73/12/08	13 50		2.800	1.100	0.168	0.028	0.095
74/01/26	13 30		3.080	0.500	0.144	0.020	0.090
74/02/09	15 00		3.520	0.600	0.165	0.015	0.065
74/02/24	14 20		3.200	0.600	0.110	0.020	0.080
74/03/10	12 40		2.100	1.200	0.105	0.025	0.105
74/03/24	13 35		2.900	0.600	0.105	0.020	0.050
74/04/07	12 45		2.600	0.600	0.130	0.022	0.045
74/05/19	11 50		2.700	0.850	0.105	0.025	0.080
74/06/02	13 00		2.300	1.500	0.155	0.026	0.090
74/07/21	13 10		2.100	1.000	0.135	0.035	0.130

STORET RETRIEVAL DATE 76/06/04

3406F1
40 59 15.0 073 58 30.0 4
DOROTOCKEYS RUN
34 7.5 YONKERS
T/ORADELL RESERVOIR 013391
TAPPAN BRDG 100 FT E OF LAFAYETTE RD JCT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	13 45		0.750	1.300	0.120	0.096	0.310
73/08/19	09 10		3.200	0.160	0.028	0.060	0.070
73/09/16	12 15		2.500	0.840	0.086	0.098	0.135
73/10/14	11 05		4.200	0.150	0.023	0.330	0.345
73/11/11	12 30		3.360	0.450	0.072	0.078	0.210
73/12/08	11 15		2.400	0.700	0.080	0.052	0.135
74/01/26	13 10		2.200	0.200	0.108	0.036	0.070
74/02/09	14 30		2.940	0.300	0.120	0.040	0.070
74/02/24	14 45		9.900	0.600	0.067	0.040	0.090
74/03/10	11 15		1.300	1.000	0.070	0.030	0.085
74/03/24	13 55		2.300	0.400	0.050	0.040	0.075
74/04/07	12 15		2.000	0.700	0.120	0.032	0.050
74/05/19	10 30		2.600	0.900	0.128	0.295	0.390
74/06/02	11 50		2.000	0.900		0.005K	0.145
74/07/21	13 15		3.700	0.700	0.040	0.350	0.470

K VALUE KNOWN TO BE
LESS THAN INDICATED

30

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1973

STATE OF NEW JERSEY

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3402	BUDD LAKE	0.082	0.205	474.000	48.500	7.400	0.012
3403	GREENWOOD LAKE	0.021	0.100	414.250	11.920	14.800	0.007
3406	ORADELL RESERVOIR	0.055	0.990	462.500	22.267	13.600	0.008
3409	PINECLIFF LAKE	0.070	0.175	465.500	38.960	11.000	0.011
3410	POMPTON LAKES	0.071	0.795	463.167	23.033	11.800	0.029
3412	DUHERNAL LAKE	0.082	1.420	466.667	6.800	8.600	0.010
3413	FARRINGTON LAKE	0.055	0.770	462.000	8.283	14.400	0.012
3415	LAKE HOPATCONG	0.022	0.120	416.333	13.627	14.900	0.007
3417	LAKE MUSCONETCONG	0.036	0.140	436.000	11.067	6.000	0.010
3419	PAULINS KILL LAKE	0.133	0.950	460.500	7.017	9.000	0.065
3420	SPRUCE RUN RESERVOIR	0.020	0.470	428.667	15.333	15.000	0.007
3422	UNION LAKE	0.063	1.150	463.200	22.080	12.800	0.018
3423	WANAQUE RESERVOIR	0.014	0.120	355.333	7.111	14.800	0.005

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3402	BUDD LAKE	12 (1)	58 (7)	0 (0)	0 (0)	92 (11)	29 (3)	191
3403	GREENWOOD LAKE	83 (10)	100 (12)	92 (11)	58 (7)	21 (2)	83 (9)	437
3406	ORADELL RESERVOIR	54 (6)	17 (2)	42 (5)	25 (3)	42 (5)	67 (8)	247
3409	PINECLIFF LAKE	33 (4)	67 (8)	17 (2)	8 (1)	67 (8)	42 (5)	234
3410	POMPTON LAKES	25 (3)	33 (4)	33 (4)	17 (2)	58 (7)	8 (1)	174
3412	DUHERNAL LAKE	12 (1)	0 (0)	8 (1)	100 (12)	83 (10)	58 (7)	261
3413	FARRINGTON LAKE	54 (6)	42 (5)	50 (6)	75 (9)	33 (4)	29 (3)	283
3415	LAKE HOPATCONG	75 (9)	87 (10)	83 (10)	50 (6)	8 (1)	83 (9)	386
3417	LAKE MUSCONETCONG	67 (8)	75 (9)	67 (8)	67 (8)	100 (12)	50 (6)	426
3419	PAULINS KILL LAKE	0 (0)	25 (3)	58 (7)	92 (11)	75 (9)	0 (0)	250
3420	SPRUCE RUN RESERVOIR	92 (11)	50 (6)	75 (9)	42 (5)	0 (0)	83 (9)	342
3422	UNION LAKE	42 (5)	8 (1)	25 (3)	33 (4)	50 (6)	17 (2)	175
3423	WANAQUE RESERVOIR	100 (12)	87 (10)	100 (12)	83 (10)	21 (2)	100 (12)	491

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3423	WANAQUE RESERVOIR	491
2	3403	GREENWOOD LAKE	437
3	3417	LAKE MUSCONETCONG	426
4	3415	LAKE HOPATCONG	386
5	3420	SPRUCE RUN RESERVOIR	342
6	3413	FARRINGTON LAKE	283
7	3412	DUHERNAL LAKE	261
8	3419	PAULINS KILL LAKE	250
9	3406	ORADELL RESERVOIR	247
10	3409	PINECLIFF LAKE	234
11	3402	BUDD LAKE	191
12	3422	UNION LAKE	175
13	3410	POMPTON LAKES	174